SUMMARY REPORT

WORKSHOP ON CLIMATE CHANGE AND WATER QUALITY IN THE GREAT LAKES REGION: RISKS, OPPORTUNITIES, AND RESPONSES

Courtyard Marriott
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NOTICE

The statements in this report reflect the views and opinions of the workshop participants. They do not represent analyses or positions of the U.S. Environmental Protection Agency (EPA).

This report was prepared by ERG, an EPA contractor, as a general record of the discussion that took place during a workshop entitled *Climate Change and Water Quality in the Great Lakes Region—Risks, Opportunities, and Responses.* This workshop was held in Detroit, Michigan, on May 28–29, 2003. As EPA requested, this report captures the main points and highlights of the meeting. It is not a complete record of all details discussed, nor does it embellish, interpret, or enlarge upon matters that were incomplete or unclear.

CONTENTS

EXECUTIVE SUMMARY

On May 28–29, 2003, the U.S. Environmental Protection Agency, in cooperation with the International Joint Commission (IJC) and Environment Canada, hosted a Climate Change workshop in Detroit, Michigan. The workshop was held to discuss a white paper, entitled *Climate Change and Water Quality in the Great Lakes Region: Risks, Opportunities, and Responses*. This white paper, which was written for the IJC's Great Lakes Water Quality Board, was released in draft form in April 2003. It was distributed to attendees prior to the workshop. During the workshop, attendees were asked to ground truth the white paper, provide feedback on the document, and recommend ways to strengthen the document. Once the white paper is finalized, it will be submitted to the Great Lakes Water Quality Board and used to advise the IJC on what it should do to address climate change issues.

The workshop took place over 2 days. Four presentations were delivered. Speakers covered the following topics: (1) impacts that climate change could have on human health, agriculture, recreation, tourism, shipping, ecosystems, and the economy; (2) research that has been performed to examine the impact that climate change could have on the Great Lakes' beneficial uses; (3) tools that policymakers require to make sound decisions about how to address climate change; and (4) the importance of investing in adaptation strategies to minimize the harmful effects or harness the positive effects of climate change. Some clear messages came through during the course of the presentations. For example, speakers made it clear that climate change is happening now and that impacts are already evident. Even if aggressive mitigation measures are implemented today, the speakers said, it is too late to prevent climate change from continuing to be a problem in future years. Thus, since change is unavoidable, it makes sense for people to do what they can to build resiliency, decrease vulnerabilities, and take advantage of opportunities presented by the impending changes. For this reason, it is imperative to invest in adaptation strategies now.

Much of the workshop was dedicated to open discussion, question and answer, and breakout group discussion. For the latter, attendees were divided into small groups to discuss the impacts of climate change, identify actions that could be taken to adapt to climate change, recommend ways to strengthen the white paper's content, and identify concrete recommendations for the Great Lakes Water Quality Board and IJC. A leader from each group presented a summary of the group discussions.

Several ideas and recommendations were offered during the breakout group summary reports and the open discussion periods. Attendees identified several ways that the white paper could be strengthened. These included: (1) adding information about the link between greenhouse gases and climate change, (2) adding more examples of the positive changes that might result from climate change, (3) placing uncertainty into context for decision makers, (4) establishing a tighter link between the section that discusses climate change projections and the section that discusses impaired beneficial uses, (5) presenting a worst-case as well as a best-case scenario in order to fully assess risks, (6) providing more information about net effects and cumulative effects, (7) including more information about the way climate change could impact the agricultural sector, (8) adding more information about the economic ramifications of climate change, (9) providing information about which adaptation strategies are most likely to succeed, (10) providing information that is relevant to managers and users, (11) discussing the possibility of ecosystem flips, (12) providing more information on the impact climate change could have on food-borne illnesses, and (13) adding more information about adaptation measures that can be used to minimize erosion. In addition, participants identified additional studies that could be incorporated into the white paper.

Workshop attendees also identified activities that the Great Lakes Water Quality Board and the IJC could undertake to address climate change issues. These included promoting education, outreach, communication, and marketing efforts; developing additional tools for decision makers; supporting scientific research and monitoring endeavors; tapping into traditional knowledge in an effort to better understand baseline conditions; developing a strategic plan; and supporting efforts to implement adaptation strategies. In addition, some workshop attendees advised the Board to engage in a robust risk assessment and risk management process.

1. INTRODUCTION

1.1 Background Information

In 2000, the International Joint Commission (IJC) identified climate change and climate variability as an issue of concern for the Great Lakes Basin. Thus, the IJC asked its Great Lakes Water Quality Board to provide information on the implications of climate change and to provide insight on what can be done to address the impending changes. To gather this information, the Board commissioned a white paper. The paper, entitled *Climate Change and Water Quality In the Great Lakes Region: Risks, Opportunities, and Responses*, was released in April 2003 in draft form. The Board will use the white paper to formulate advice for the IJC on how best to address climate change issues; as part of this process, a stakeholder workshop was organized to obtain feedback on the white paper. The workshop took place on May 28–29, 2003, and was held at the Courtyard Marriott in Detroit, Michigan. More than 50 people attended. (The workshop participant list is included as Appendix A.) The U.S. Environmental Protection Agency's (EPA's) National Center for Environmental Assessment, Office of Research and Development, organized the workshop in cooperation with the IJC and Environment Canada.

1.2 Agenda

The workshop took place over 2 days. The agenda is provided as Appendix B. Four presentations were delivered over the course of the workshop. (The presentations can be viewed by visiting http://www.ijc.org/boards/wqb/index.html, clicking on the "Report" button, and then clicking on "Climate Change Workshop May 2003—Presentations.") In addition, participants broke into small discussion groups twice during the course of the workshop. During these breakout sessions, attendees were asked to discuss the impacts of climate change and to identify actions that could be taken to adapt to climate change. (Appendix C provides a list of the questions that the breakout groups were asked to address. It also includes a list of the people who participated in each breakout group.) After each breakout session was completed, the attendees reconvened as one group and a facilitator from each of the breakout groups came to the front of the room to provide a summary of the group's discussions. At several points during the workshop, the floor was opened up to the general audience for questions and comments.

1.3 Welcome and Introductions

Dennis Schornack, Chairman of the U.S. Section of the International Joint Commission

On behalf of the IJC, Dennis Schornack welcomed attendees to the Climate Change Workshop. He provided a brief summary of the IJC's history and noted that the IJC is interested in learning more about climate change issues. The IJC, a binational organization that was formed by the Boundary Waters Treaty of 1909, operates under the direction of six commissioners—three from the United States and three from Canada. Although the Commissioners are appointed by the U.S. President (with the advice and consent of the Senate) and the ministers of the Canadian Cabinet (with the advice and consent of the Canadian Prime Minister), when the Commissioners assume office, they take an oath to act independently of their governments. Thus, the IJC operates as an independent organization. The IJC's goal is to work in a collaborative fashion to maintain the water resources that Canada and the United States share. The IJC also strives to resolve disputes through processes that seek the common interests of both countries. The IJC operates all along the Canadian–United States border, Schornack said, noting that the Great Lakes region is of key interest to the Commission.

The Great Lakes Water Quality Agreement of 1972 mandates that the IJC restore and maintain the chemical, physical, and biological integrity of the Great Lakes Basin Ecosystem. As a result of the agreement, two binational boards—the Great Lakes Water Quality Board and the Great Lakes Science Advisory Board—were established to provide advice to the IJC on matters pertaining to the Great Lakes. On a periodic basis, the IJC develops a list of issues that it wants the Great Lakes Water Quality Board to focus upon. Two years ago, the IJC instructed the Board to examine the effects of climate change. The Board embraced the challenge and supported the development of a white paper. Schornack said that a draft version of the white paper had been completed and would be the subject of discussion during this workshop. The Great Lakes Water Quality Board will use the final version of the white paper to formulate advice for the IJC on what to do about climate change issues.

1.4 Purpose of the Workshop

David Ullrich, U.S. co-chair of the Great Lakes Water Quality Board
John Mills, Canadian co-chair of the Great Lakes Water Quality Board

David Ullrich and John Mills, co-chairs of the Great Lakes Water Quality Board, also welcomed attendees to the workshop. They provided additional information about the workshop's objectives and explained why climate change is an important issue. Ullrich set the tone for the workshop by noting that climate plays an important role in day-to-day human life and the functioning of the entire ecosystem. He said that a changing climate could have dramatic implications for the Great Lakes, a resource that is already under a significant amount of stress from factors like pollution, eutrophication, invasive species, and acid rain. Over the course of the workshop, attendees would explore the impacts that climate change could have on air quality, water quality, water supply, soil quality, human health, ecosystem health, resource use, and the economy.

Mills noted that when the IJC asked the Great Lakes Water Quality Board to examine climate change issues, the Board identified some experts and asked them to develop a white paper that answered the following questions:

What Great Lakes' water quality issues are associated with climate change?
What are potential impacts of climate change on the 14 beneficial uses identified in the Great Lakes Water Quality Agreement?
How might impacts vary across the Great Lakes region?
What are the implications for decision making?

A draft version of the white paper has been completed, Mills said, noting that the authors—Linda Mortsch (Environment Canada), Marianne Alden (University of Waterloo), and Joel Scheraga (EPA)—had done an excellent job pulling together a large quantity of information. He said that all of the attendees should have received a copy of the white paper prior to the workshop. As the workshop unfolded, attendees would be asked to ground truth the white paper, provide feedback on the document, and recommend ways to strengthen the document. Attendees would be called upon to think outside the box, share their insight and experience on climate change issues, provide information on real-world effects they have already observed, and recommend measures that could be taken to address impacts. Mills listed two concrete things that would come out of the workshop. First, the white paper authors would consider the workshop participants' comments when they revise the white paper. Second, the workshop proceedings would be summarized, attached to the white paper, and used to assist the Great Lakes Water Quality Board in developing advice for the IJC on what to do about climate change issues.

2. IMPACTS OF CLIMATE CHANGE ACROSS THE GREAT LAKES REGION

Linda Mortsch and Marianne Alden provided an overview of the white paper's major findings. They talked about the types of changes that might occur in the Great Lakes region as the climate changes, and they described the impacts that these changes could have on a variety of important systems.

2.1 Climate Change and Water Quality in the Great Lakes Region

Linda Mortsch, Environment Canada

Mortsch opened by noting that the white paper embraces an ecosystem perspective: rather than focusing solely on water quality, the authors examined the impact that climate change could have at the ecosystem scale, and how the impacts could affect a variety of systems, including water resources, human health, agriculture, recreation, and the economy. Mortsch said that her presentation would focus on the impacts that a changing climate could have on the Great Lakes Basin. While listening to the presentation, she said, audience members should ask themselves the following three questions: What impacts are of concern to me and my stakeholders? What adaptation measures need to be implemented? How can we facilitate adaptation?

Modeling exercises and various studies indicate, Mortsch said, that climate change could lead to significant airshed effects, nearshore effects, inlake effects, and watershed effects. As air temperature rises, the following is projected: (1) the frequency and intensity of storms will change, (2) more precipitation will fall on an annual basis but less will fall during key growing seasons, (3) high-intensity precipitation events will be more frequent, (4) evaporation and evapotranspiration rates will increase, (5) there will be less ice cover on lakes, and (6) there will be less snowfall (and therefore less snow pack) and more rain during the winter season. Mortsch indicated that these effects could have significant implications on ecosystems and biodiversity, recreation and tourism, agriculture, streamflow, lake levels, ground water, and human health.

Ecosystems and Biodiversity

Mortsch noted that thermal conditions and precipitation patterns—both of which are projected to change—set the boundaries which determine where different types of wildlife and vegetation are able to live. As the boundaries change, some types of habitat will be lost, some types of habitat will expand, and existing community structures and interactions will likely be altered. While some animals and plants might find that climate change brings them new opportunities, other organisms could be adversely affected. For example, studies suggest that southerly species of warm-water fish might be able to supplant northerly species of cold-water fish. Mortsch presented some maps which showed how the distribution of bobolink (a bird species) could change in the future. She also presented maps that showed how vegetation zones might change in a two times carbon dioxide ($2 \times CO_2$) climate change scenario. The scenario suggests that existing forests might become severely stressed and that their boundaries could be altered due to changed climate conditions. Expanding on the topic of forestry, Mortsch said that climate change might induce a major shift in the range of tree species, and that it has the potential to degrade forest health, promote harmful plant diseases and pests, cause increases in forest fires, and induce changes in water availability and water quality.

Mortsch pointed out that rare and endangered species, which may be few in number and have a small range and/or limited habitat, might be particularly vulnerable to the stress of a changing habitat. In addition, non-native species might be able to gain strong footholds as the climate changes. Mortsch used zebra mussels as an example to drive home her point. Although zebra mussels have already been introduced to Lake Superior through bilge water, the species does not currently flourish in the lake because the water is too cold. What will happen, she asked, if Lake Superior's water temperature rises?

Recreation and Tourism

Mortsch said that climate change could cause dramatic shifts in the recreation and tourism industry. For example, because climate change is expected to result in longer summers and shorter winters, the season for summer time activities (e.g., camping, boating, and hiking) will lengthen, but the season for winter sports will be curtailed. A shorter winter season would harm the skiing industry, Mortsch said, noting that ski resorts would have a shorter reliable season and would have to rely on costly snow-making activities. Even those who manage summertime activities might face some tough management issues. For example, if the hiking season is longer, will resource managers have to limit access to trails to protect them from overuse and damage? Also, if climate change causes adverse effects, such as poor water quality, low water levels, species loss, or aesthetic problems, will hunting, bird watching, fishing, swimming, or canoeing still be desirable activities?

Agriculture

While it is true that climate change could result in a longer growing season, Mortsch said, a warmer climate might induce some negative effects on the agricultural industry. For example, irrigation demand could increase since precipitation during key seasons, such as summer and fall, might decrease as the climate changes. Also, some projections suggest that warmer temperatures will support the growth of more pests and weeds. If this is true, then the additional pesticides and herbicides that will be needed to address the problem will come at a cost to farmers and also cause environmental concerns. In addition, an increase in soil erosion is projected to occur because high-intensity rainfalls are expected to increase, winter rainfall is expected to increase, and snow cover, which acts as a barrier to erosion, is expected to lessen. As a result, water quality will be affected. Also, climate change might require a change in the type of crops that are grown and the types of tillage practices that are used.

Streamflow

Studies suggest that climate change will also cause changes in the timing and amount of streamflow. While more water is expected to run off the land and flow through streams during the winter months, the low-flow events of the summer and fall seasons are likely to be exacerbated. Not only will these changes affect water quality, but they could also increase the likelihood of conflicts erupting about the way water is apportioned for different uses, such as instream ecological needs and economic uses. Mortsch presented the results of a modeling exercise that was performed on the Trent River. The results suggest that summer flow might be reduced by as much as 22 percent in 2030, 37 percent in 2050, and 55 percent in 2090.

Lake Levels

Mortsch said that most climate change scenarios project that water levels in the Great Lakes will decrease. While some models predict decreases of about 22 centimeters, others anticipate a drop of 2.5 meters. Low lake levels could have negative impacts on transportation, tourism, recreation, fisheries, industry, municipalities, agriculture, and human health. (See Figure 3.6 in the white paper for more details.) Changing water levels could also have dramatic impacts on wetlands and the types of plants and animals that live in such environments. Mortsch presented a figure that showed how the shoreline of Lake St. Clair would be impacted by a water level decrease of 1.6 meters. Such an event could shift the location of the shoreline by 0.5 to 6 kilometers. She also noted that such a drop in water level could have impacts on the shipping channel and cause more boats to run aground. (Already, Mortsch said, at least one boat salvage company has experienced a boost in business as more boats have started running aground because of low water levels.)

Ground Water

Mortsch said that some studies suggest that climate change could cause decreases in ground-water recharge, levels, and base flow. If so, this would cause changes in the amount and timing of base flow to streams, lakes, and wetlands. The studies also suggest a seasonality effect. Less flow is expected during critical times, such as spring and early summer, and more flow is expected during the wintertime. The proportion of ground water in stream flow is also altered.

Water Quality

Climate change could have dramatic impacts on water quality. Increases in water temperature, Mortsch reported, could affect physical, chemical, and biological processes. Some work suggests that there will be extended thermal stratification and less mixing, increasing the potential for anoxia by raising the metabolic rates of invertebrates and microbes. All of these factors could affect water quality. Non-point source pollution is also expected to become a more significant problem as the climate changes. Mortsch noted that the Soil and Water Conservation Society recently released a report stating that increases in precipitation intensity could lead to greater erosion and entrainment of sediments, nutrients, and pesticides. She said that point source pollution might also pose a more serious problem as the climate changes, noting that such reductions in flow and increases in low-flow episodes could reduce assimilative capacity and make it more difficult for point sources to meet existing water quality standards for discharge. A climate change impact assessment of the Bay of Quinte Watershed illustrates that the Remedial Action Plan (RAP) water quality remediation targets for phosphorus might not be met.

Human Health

Mortsch asserted that climate change will likely affect human health. For example, she said, humans could be affected by: (1) increases in extreme weather events, such as flooding and ice storms; (2) increases in heat stress episodes and decreases in cold stress episodes; (3) increases in vector-borne and rodent-borne diseases; and (4) poor air quality. Expanding on the latter, Mortsch noted that ground-level ozone, which causes adverse health effects, becomes a bigger problem as temperatures rise. The people who might be the most vulnerable to health risks are children and the elderly, as well as low-income and immuno-compromised individuals. Mortsch also noted that climate change could cause water quality impairment from combined sewer overflow. She said that combined sewer systems, which service many cities in the United States and Canada, contribute pollutants, including bacteria, into water bodies during intense high-runoff precipitation events. As the climate changes and the frequency of high-intensity rain events increases, more combined sewers overflow pollution incidents are anticipated

2.2 Implications for the Beneficial Uses Identified in the Great Lakes Water Quality Agreement

Marianne Alden, University of Waterloo

Alden opened by noting that the Great Lakes Water Quality Agreement calls for the cleanup and restoration of 14 impaired beneficial uses. She also indicated that there are currently 42 Areas of Concern (AOCs) in the Great Lakes.[1] She defined AOCs as "geographic areas that fail to meet the general or specific objectives of the [Great Lakes Water Quality] Agreement where such failure has caused or is likely to cause impairment of beneficial use of the area's ability to support aquatic life." Alden said that it is important to analyze the impact that climate change could have on the Great Lakes' beneficial uses and AOCs. Three key questions

[1] Since the workshop, one AOC (i.e., Severn Sound) has been deregulated. Thus, there are now 41 AOCs in the Great Lakes Region.

require attention: Will climate change impact areas that have already been deemed environmentally sensitive? Will changes in climate create new AOCs? and Will climate change impair beneficial uses that have already been restored?

The white paper summarizes research that has been performed to examine the impact that climate change could have on the Great Lakes' beneficial uses. Information and references were presented for the following 12 beneficial uses:

Loss of fish and wildlife habitat. Alden reported that fish and wildlife habitat have been studied to examine the impacts of changing water levels, precipitation patterns, air temperatures, ice break up patterns, and disturbance hazards (e.g., forest fires and insect outbreaks). Some studies suggest that: (1) the aerial extent of wetlands will be altered as water levels change; (2) tree lines will shift and certain tree species will disappear as air temperatures change; and (3) channel morphology could be altered due to changes in ice break-up intensity and this could affect vegetation succession and fish spawning habitat along the shoreline.

Degradation of phytoplankton and zooplankton communities. According to existing research, Alden said, plankton populations appear to be sensitive to: (1) warmer air and water temperatures, (2) drier hydrological conditions, and (3) changes in ice break up. For example, some studies show that colder waters support larger and more diverse plankton populations.

Added cost to agriculture and industry. Alden said that no research has been performed to determine exactly how climate change will impact costs incurred by the agricultural and industrial sectors.

Degradation of aesthetics. Alden said that no specific research has been performed to examine how climate change could affect aesthetics. Some studies do suggest, however, that decreases in water level result in shoreline changes that are not aesthetically pleasing, such as exposed and rotting vegetation and muddy shorelines and mudflats.

Beach closings. Alden said that no specific research has been performed on the effect that climate change is expected to have on beach closings. Some studies do suggest, however, that beaches are negatively impacted by increased precipitation events and lower water levels. For example, in July 1998, an intense rainstorm washed waste from the street and caused sewage plant overflows. This resulted in the closure of almost every beach in Kingston, Toronto, Hamilton, and St. Catharines.

Restrictions on drinking water consumption or taste and odor problems. According to existing research, Alden said, impairments of this sort have been linked to air temperature increases and low water levels.

Eutrophication or undesirable algae. Alden said that all of the following factors have been shown to play a role in increasing eutrophication rates and promoting algal blooms: (1) increases in air and water temperatures, (2) decreases in water levels, and (3) increases in high-intensity precipitation events.

Restrictions on dredging activities. While no specific research has been performed on the effect that climate change will have on the dredging industry, Alden said, some studies do suggest that problems, such as resuspension of sediment, are exacerbated as water levels decrease.

Degradation of benthos. While no specific research has been performed on the effect that climate change will have on benthos populations, Alden said, some studies do suggest that these populations are impacted by changes in water quality.

Degradation of fish and wildlife populations. Alden said that a significant amount of research has been performed on this topic. The results suggest that fish and wildlife populations are affected by increases in water and air temperature, invasions of non-native species, changes in water chemistry, and changes in food sources. To expand on these points, she provided some examples. The sex ratio of painted turtle populations is affected by air temperature, she said, noting that more females are born when conditions are warmer. Also, the warming of water temperatures, might allow: (1) sea lampreys to thrive, and (2) cold-water fish to be driven out of their habitats by warm-water fish. In addition, warmer temperatures have been known to prompt some species to mate or migrate early. In the case of the latter, an animal might arrive at its destination before its food source is available.

Restrictions on fish and wildlife consumption. Alden said that no specific research has been performed on the effect that climate change could have on this topic.

Tainting of fish and wildlife flavor. Alden said that no specific research has been performed on the effect that climate change could have on this topic.

Alden concluded by saying that she hoped her presentation would help attendees see where there are gaps in the knowledge base.

2.3 Discussion

Mills thanked Mortsch and Alden for their insightful presentations and invited workshop participants to ask questions or recommend modifications, additions, or deletions to the white paper. Audience members' comments fell into two categories: recommendations and questions/comments.

Recommendations for the White Paper

Workshop participants suggested doing the following to strengthen the content of the white paper:

Incorporate information about: (1) the link between climate change and greenhouse gas emissions, and (2) the importance of mitigation strategies. Milt Clark complimented the authors on a job well done, but said that some key points have been omitted from the white paper. He recommended adding information at the beginning of the document about the link between greenhouse gas emissions and climate change. As the white paper is currently written, he said, the document simply states that temperatures are increasing. No explanation is provided as to why this is the case. Such an omission, Clark said, deprives readers of a full understanding of climate change issues. Clark acknowledged that the exact role that greenhouse gas emissions play in climate change is controversial and agreed that it would be unwise to get sidetracked in a lengthy debate on the subject. At a minimum, however, the white paper should state that the Intergovernmental Panel on Climate Change (IPCC) and the National Academy of Sciences (NAS) have concluded that greenhouse gas emissions contribute to global climate change. Because the white paper does not currently make this point, it automatically discourages discussion on greenhouse gas mitigation efforts. Clark said that this was a big mistake and he recommended providing some examples of mitigation measures to make the white paper intellectually complete. It would be particularly useful, he said, to highlight positive "win-win" strategies. He cited efforts to promote energy efficiency as an example; not only does this strategy reduce greenhouse gas releases, he said, but it also helps people save money and reduce air pollutants at the same time. Clark also recommended making it clear that Canada and the United States are actively involved in greenhouse gas reduction efforts.

After thanking Clark for his comments, John Carey indicated that the authors had been instructed to steer clear of the greenhouse gas emission debate and the topic of mitigation strategies. There was concern, Carey said, that the controversy associated with these topics would overshadow the other important points that are addressed in the white paper. For this reason, the Great Lakes Water Quality Board instructed the authors to ignore these topics and to use the following as a starting point: climate change *is* a reality, it is happening *now*, and it is time to start examining whether communities are equipped to adapt to climate change. For this reason, Carey said, the document focused on adaptation measures rather than mitigation measures. Clark said that he could appreciate Carey's perspective, but said that he still thought a brief discussion should be included on the link between climate change and greenhouse gas emissions and the importance of mitigation strategies. Mills said that Clark's points would be taken into consideration.

Include information about changes observed in Green Bay. Victoria Harris said that a recently published paper indicates that there has been a shift over the last 13 years in summer windfield patterns and storm events across Green Bay, an area heavily contaminated with polychlorinated biphenyls (PCBs). Harris said that these changes could affect circulation patterns, water retention times, resuspension rates, sediment transport, and could affect the amount of time it takes for Green Bay to recover *via* natural sedimentation and PCB burial. Such changes, Harris said, could have important ecological, water quality, and human health ramifications. For example, she said, changes in sediment burial rates could lengthen the time it takes for fish tissues to recover from PCB contamination. Harris recommended reviewing the Green Bay study to determine whether it should be incorporated into the white paper.

Include more discussion about the positive effects of climate changes. In some cases, Harris said, climate change might induce beneficial changes. For example, in some areas, fish productivity could increase with rising temperatures. While the white paper does acknowledge that there will be winners and losers, Harris said, little emphasis is placed on the "win" part of the equation and few examples are provided of potential positive effects. Harris said that her comments should not be misconstrued as some sort of endorsement for activities that promote climate change. She does think it is important to present a fair and balanced picture of the projections, however.

Include information on the role that the speed and magnitude of change has on a species' ability to adapt to climate change. Ullrich said that he has heard that species will have more trouble adapting to climate change if the change occurs rapidly rather than gradually. He recommended exploring this topic in greater detail in the white paper. He also asked whether the climate is changing more rapidly now than in the past, and if so, whether information of this sort could be added to the white paper. Mortsch said that several researchers are interested in the questions that Ullrich posed, but that little concrete information is currently available on the subject. Mortsch said that more research needs to be performed on how adaptable humans and ecological systems are to the rate of change.

Put uncertainty into context for decision makers. Beth Lavender said that some decision makers are reluctant to invest in adaptation strategies because of the uncertainty that is associated with global climate change projections. She advised reviewing IPCC documents for input on how to place uncertainty into proper context for decision makers. Mortsch said that she does not think the IPCC has reached consensus on how to characterize uncertainty yet. She did say that she thinks decision makers are gradually becoming more willing to consider adaptation strategies. While no one was willing to talk about adaptation strategies 10 years ago, Mortsch said, the topic is now gaining attention.

Make it clear that the cumulative effects of climate change could cause some areas in the Great Lakes to re-experience problems. Carey expressed concern that the negative impacts of climate change could be additive and place heavy stress on particular areas. For example, Carey said, he is concerned that the combined effect of lower water levels and longer periods of stratification could place areas at increased risk of anoxia. Over the years, he said, many efforts have been undertaken to combat anoxic conditions. Will the strides made in this area, he asked, be undermined by the cumulative effects of climate change? Mortsch said that Carey's concerns are valid.

Differentiate between physical habitat (the substrate) and overlying water. John Gannon commented on the water habitat research that Alden presented. He advised differentiating between physical habitat (the substrate) and overlying water. He also noted that much more research is needed on the nearshore effects of climate change.

Questions/Comments

Are governments, agencies, and private organizations structured in a fashion that promotes an "ecosystem approach" to management and the ability to adapt to climate change? Paul Gray commended the authors for their efforts to show that the effects of climate change are interconnected and that the impacts will touch many different sectors. He praised them for taking an ecosystem perspective when writing the paper. Gray noted that the cumulative nature of the impacts will make it more difficult to develop action-oriented adaptation management plans. He asked the authors to comment on this point and to indicate whether society is equipped to address climate change using a comprehensive ecosystem approach. Mortsch said that she was not sure whether governments were fully equipped to do so yet, but she did say that she is heartened to see that governments and other organizations have started taking climate change seriously. Much progress has been made, she said, in getting stakeholders to the table. Also, the concept of adaptation is starting to take firm root.

Did the authors examine how climate change might impact the volatilization of contaminants? A variety of volatile contaminants are in the Great Lakes. Research has shown, Jim Bruce said, that high temperatures promote the volatilization of these contaminants. This leads him to believe that some aspects of climate change could benefit the Great Lakes. Unfortunately, he said, northern communities, such as the peoples of the Arctic, might suffer as a result because the Great Lakes' volatile compounds would likely be redeposited in more northerly colder waters. Bruce asked whether these issues had been discussed among the white paper's authors. Mortsch said that the white paper does not tackle this issue. Mills said that some research is being performed in this area, but no definitive conclusions have come forth yet. Carey said that it will be difficult to predict how climate change will impact volatilization and redeposition patterns. This is due, in part, to the fact that volatilization rates are dependent on relative concentrations and relative temperatures. For parts of the year, he said, Lake Superior acts as a sink for volatile contaminants; at other times of the year, it is a source. Carey also noted that it is difficult to predict how contaminants will volatilize. For example, some pesticides volatilize only at night, a finding that took researchers by complete surprise since volatilization rates typically peak during the heat of the day.

Is it acceptable to have so many gaps in the knowledge base? Commenting on the presentation that Alden delivered, Enos Whiteye noted that several of the topical areas that she discussed had barely been researched. Many holes still exist in the knowledge base. Is this satisfactory, he asked? Mortsch said that it is not and that the authors would like help filling in data gaps. Whiteye asked whether the authors planned to conduct their own research to fill in the gaps or whether they were waiting for community members to take the lead. At this point, Mortsch said the authors are just trying to let the community know where information is lacking. In addition, Mortsch noted that the authors are not

certain that the white paper captures every single study that is available. Thus, they are hoping that the workshop participants will let them know if any studies are missing from the reference list. (The authors are interested in published literature as well as "gray literature.")

Did the authors consider unexpected transient effects? Carey said that it is impossible to predict all the impacts of climate change. Surprises are to be expected. He asked whether efforts are underway to look for examples of interesting surprises that have already emerged. These issues are not discussed in the white paper, Mortsch said, but are hinted at in a past volume of *Limnology and Oceanography*.

3. CLIMATE CHANGE FROM A USER'S PERSPECTIVE

Mills introduced Georges Beauchemin, the luncheon speaker. Beauchemin has direct experience dealing with dramatic storm events, which are expected to increase in frequency as the climate changes. As the Director General of Municipal Affairs under Quebec's Department of Public Security, Mills said, Beauchemin played a major role in addressing the disastrous 1996 flooding of the Saguenay River, the 1999 ice storm that impacted western Quebec and eastern Ontario, and the 2000 avalanche in the Inuit village of Kangiqsualujjuaq, Quebec. Mills said that Beauchemin also participates as the chair of Ouranos, a consortium created in 2002 to promote the acquisition of expertise that will advance understanding of regional climate change and its environmental, social, and economic impacts. Mills said that Beauchemin's presentation was designed to stimulate audience members to "think outside the box" on climate issues and to explore activities that governments and other organizations can undertake to address climate change.

3.1 Crossborder Tools and Strategies

Georges Beauchemin, Director General of Quebec's Ministére de la Sécurité Publique and Chair of Ouranos

Beauchemin opened his presentation by saying that climate change is already happening and it will continue to be a problem in the future. While many of the potential impacts are unclear, he said, one thing is certain: there is going to be damage and it is going to be long lasting. Even if greenhouse gas emissions were stabilized immediately, the earth could still experience a changing climate and sea-level rise for more than 1,000 years into the future. Stabilization is not expected any time soon even though many countries have adopted the Kyoto Protocol. Citing reports issued by the IPCC and the U.S. Department of Energy (DOE), Beauchemin said that CO_2 emissions are expected to increase as the world's energy demands increase, particularly in Southeast Asia and China. The IPCC has indicated that there is currently 1.3 X CO_2 in the atmosphere. (1.0 X CO_2, the level of CO_2 present in 1750, is considered the natural base level.) IPCC predicts that humans must achieve 10 times "Kyoto" in order to prevent the world from reaching a 4.0 X CO_2 level. If very aggressive mitigation strategies are implemented, Beauchemin said, humans may be able to keep the levels down to a 2.0 X CO_2 level. This represents the best-case scenario. At a minimum, this is the world to which risk managers and decision makers should plan to adapt. The 2.0 X CO_2 scenario will create a new climate that scientists know little about. Still, at this level, scientists are able to make reasonable predictions about potential outcomes. This is not the case, however, for the 4.0 X CO_2 scenario, which Beauchemin described as a non-linear unknown climate that cannot be easily modeled.

After presenting information about what to expect in the future, Beauchemin moved on to discuss the implications this has for decision makers, policymakers, and planners. He acknowledged that such populations are in a "catch 22." While it is risky to base planning activities on the best-case scenario (i.e., 2 X CO_2), it is also risky to plan for more dramatic scenarios if their potential impacts are not well understood. What strategy is best to adopt, Beauchemin asked, in light of all these risks? Answering his own question, he said that it is imperative to adopt both mitigation and adaptation strategies immediately. He asserted that decision makers need to stop arguing and start working together to implement thoughtful strategies. In order to do this, they require better predictive capability and a variety of tools to help with the decision making process. Beauchemin said that Ouranos is committed to providing these tools and acquiring the knowledge that is needed to better understand climate change, climate variability, and the implications that might result. He listed the major stakeholders who are participating in Ouranos and described some of the partnerships that have been forged. (See http://www.ouranos.ca for details.) He said that Ouranos, which is located in Montréal, employs about 90 people, has access to large data banks and pools of technical expertise, supports a small supercomputer facility that runs Canada's regional climate model, and operates on a budget of about $3.85 million (Canadian dollars) per year. Ouranos is currently working on 14 projects. Each project is led by a coordinator that champions the project and is staffed by Ouranos employees and people from various

stakeholder groups. About 250 people are currently working on the 14 projects. Beauchemin hopes that the network will grow 10-fold in the future.

Beauchemin discussed some of the issues that climate change poses to Canada and the United States. He discussed issues of concern for Quebec, the Great Lakes area, prairie areas, Hudson Bay, the Labrador Sea area, the Atlantic seaboard, the northeastern states, and the rest of the United States. He said that the United States and Canada have common concerns and that it makes sense for the two countries to coordinate when developing adaptation strategies. He provided one example of the way that the countries are already cooperating. Recently, several northeastern states and Canadian provinces entered into a partnership to help each other respond to disasters. With this agreement in place, rescue crews and emergency responders can cross borders to help their neighbors. While on the topic of disasters, Beauchemin described an event that occurred in Quebec to drive home the point of how devastating and costly disasters can be. In 2000, he said, an avalanche struck a school in an Inuit village. Nine people were killed, and about one-third of the village was picked up and moved as a result. This cost about $35 million. Beauchemin said that many more disasters are expected as the climate changes. This is why it is so important to establish cooperative partnerships to address disasters.

Beauchemin said that the following are vulnerable under a changing climate: electricity generation, water management, fresh water supplies, transportation networks, agriculture, forestry, fisheries, recreation, human health, habitat, and aboriginal livelihoods and lifestyles. He provided examples to emphasize how vulnerable these systems are. First, in a discussion about fisheries, Beauchemin noted that Northern Cod stocks have been destroyed and that shellfish could be next on the list. Agriculture is also vulnerable; some researchers believe that there will be a 17 percent decline in corn and soybean crop yields if the growing season increases by just one degree. Also of great concern, are predictions that the Great Lakes' water level is expected to drop under a changing climate. If this occurs, this would have huge impacts on shipping, an industry that many other industries in the Great Lakes region depend upon. Beauchemin said that more discussion on potential impacts is available in *Confronting Climate Change in the Great Lakes Region*, a report that was written by The Union of Concerned Scientists and The Ecological Society of America. Given the severity of the concerns, it is important for people to start implementing adaptation measures, a process that requires sound risk assessment, uncertainty analysis, and well-informed decision making. Beauchemin presented the cycle, as described by the UK Climate Impacts Programme, that decision makers go through to identify appropriate adaptation measures: identify the problem and objectives, establish decision making criteria, assess risk, identify options, appraise options, make a decision, implement the decision, and monitor the outcome.

Beauchemin focused his attention back to the discussion about what Ouranos is doing to support decision makers. He said that three groups require outreach on climate change issues: the general public, the managers, and "the brass". He defined the latter as insurers-endorsers, lenders, investment people, and governance teams. This is the main group that Ouranos responds to, he said, noting that this group requires: (1) a quantified, integrated, and combined picture of their exposure to climate change itself; and (2) more information about climate policies and their impact on the bottom line. To assist this group, Beauchemin said, Ouranos is trying to develop better risk assessment tools. Toward this end, Ouranos combines climate information (obtained through dynamic models) with economic analyses that are tailored to the user's needs and concerns. Within 10 years, Ouranos hopes to develop probabilistic models. A 10- to 15-fold increase in brain, data, and dedicated supercomputer power will be needed to make this goal a reality. Beauchemin also discussed the importance of investing in dynamical downscaling, but noted that there are currently only two consortiums—Ouranos and Prudence—making such an investment.

Beauchemin presented some recommendations for Canada. First, Canada should develop a Science Plan that describes what it plans to do to address climate change issues. Also, the government should make a concerted

effort to install more climatic, oceanic, and geophysical monitoring stations in northern Canada and to collect more monitoring data both at the ground level and across a vertical profile.

Beauchemin concluded by talking about the benefits and the importance of developing a crossborder strategy between the United States and Canada. He said that it would be useful to strive to do the following over the next 5 to 10 years: (1) supply stakeholders with credible regional scenarios of probable evolution of water levels, and (2) develop and deliver timely knowledge that is tailored to specific stakeholder needs and concerns. He closed by posing the following question: Is anybody interested in coupling a catch-basin and run-off model of the Great Lakes Basin with the dynamical downscaling model, as a practical first step towards a crossborder strategy?

4. BREAKOUT SESSION #1—THE IMPACTS OF CLIMATE CHANGE

Marty Bratzel asked the workshop participants to split into five groups: the Environmental Quality/Watershed Management Group, the Municipal/Urban Group, the Resource/Resource Use Group, the Ecosystem Health Group, and the Human Health Group. He asked the groups to validate the information presented in the white paper and to provide advice on what should be done to better understand climate change impacts, obstacles, and science gaps. To help guide the breakout discussion sessions, Bratzel recommended answering the following:

Based on your experiences, what changes do you foresee in the short, medium, and long term?

The white paper identifies impacts, both positive and negative, on the Great Lakes. Considering impacts in the broadest possible terms, including but not limited to food web alteration, human health, social and economic concerns, what impacts have you experienced?

These questions were simply offered as a tool for initiating discussion, Bratzel said, noting that breakout group members should feel free to broach other questions as well. Bratzel assigned a facilitator and a rapporteur to each group, and gave the groups 2 hours to discuss the impacts of climate change.

4.1 Summary of the Breakout Group Discussions

At the end of the 2-hour session, Mills called the attendees back together and asked the breakout group facilitators to form a panel at the front of the room. Each provided a summary of the key messages, points, and recommendations that emerged from their group discussions.

Environmental Quality/Watershed Management Group

Gail Krantzberg, the Environmental Quality/Watershed Management Group's facilitator, said that the group had one recommendation for the white paper authors: establish a tighter link between the section that discusses climate change projections and the section that discusses impaired beneficial uses. Group members stressed that the IJC needs to have a clear understanding of the way changes in hydrology, temperature, precipitation, water level, and ice cover could impair beneficial uses.

In addition, Krantzberg said, group members discussed the following topics:

Watershed planning and management are important. Group members agreed that issues should be addressed at the watershed level when trying to manage and adapt to the various stressors associated with climate change. They also agreed that watershed planning is important and that better scenarios and modeling tools are needed to predict impacts at the watershed level.

Climate change is just one of many elements stressing the Great Lakes. A myriad of stressors affect ecosystems, one of which is climate change. When developing management plans, Krantzberg said, it is important to examine the interconnectedness of the stressors rather than designing plans that address only one specific stressor at a time.

More effort should be invested in land use management and planning activities. In order to prepare communities for climate change, group members agreed, it is important to improve land use models and land management planning activities. For example, communities that strive to address flash flooding and runoff issues now will be better positioned to address future climatic changes.

Climate change could have detrimental impacts on water quality. Krantzberg said that group members talked about the negative impact that climate change could have on water quality. As the frequency of high-intensity storm events increases, runoff events will increase, combined sewer systems will overflow more often, and sanitary infrastructure systems will be overtaxed. All of this will result in more toxins and pathogens entering the Great Lakes, and could lead to higher bacterial counts, beach closings, and poor water quality.

The term "adaptation" is problematic. Although group members firmly support the idea of implementing adaptation strategies to address climate change, some concern was expressed about the term *adaptation*. Some group members felt that the word will give the public the impression that climate change will be easy to manage and that society will be able to carry on business as usual once some simple adjustments are made. Such an interpretation is false, Krantzberg said.

Expect the unexpected and do not be paralyzed by uncertainty. Krantzberg acknowledged that much is still unknown about the way that climate change will impact the environment. Thus, she said, communities need to expect the unexpected and develop flexible plans that can be adapted to address changing conditions. Krantzberg said that some people are reluctant to do anything to prepare for climate change and believe that action should be postponed until the magnitude of the impacts is more certain. This stance is unwise, Krantzberg said, noting that uncertainty is inevitable and is no excuse for inaction. She concluded by saying "the perfect is the enemy of the good, so let's get on with it."

Municipal/Urban Group

John Carey, the Municipal/Urban Group's facilitator, said that group members offered the following comments about the white paper:

A less optimistic scenario should have been used when describing projected outcomes. The white paper frequently cited modeling results that were generated using a 2.0 X CO_2 scenario. Some group members felt that this represents the best-case scenario and is not necessarily realistic. Risk managers need to know, Carey said, what to expect under a less-optimistic scenario or even a worst-case scenario.

It would have been useful to provide more information about net effects. The white paper provided a detailed account of different effects that might result from climate change. Group members noted that some of the effects could cancel each other out. For example, Carey said, if you look on an annual basis, it is unclear whether climate change will cause an increase or a decrease in sediment loading. While there might be more loading during the stormy season as the intensity and frequency of storms increase, there could be less loading during the dry season as the intensity of droughts increase. Analyses like this are not currently provided in the white paper.

Carey said that the Municipal/Urban Group also made the following points:

Urban managers need tools that integrate more robust spatial and temporal scales. Many models examine issues at the suburban scale. Carey said that urban managers require tools that expand the geographical and temporal scales. The tools that are currently available do not provide adequate scales.

Urban infrastructure cannot be modified overnight. Municipal infrastructure typically has a long service life. Thus, it is not easy to overhaul infrastructure in short order. As a result, even in situations

where decision makers agree that it is necessary to adapt to climate change, it could take decades for infrastructure to be modified.

Top priority should be given to adaptation strategies that address human health and the protection of property. Carey said that it makes sense to prioritize adaptation schemes based on their likelihood of success, and that some group members thought adaptation strategies that protect human health and property are more likely to succeed than those that aim to manage ecosystems. Carey said that ecosystems manage themselves and that history shows that humans have little success when they try to intervene with these systems. (Carey said that it is unclear how realistic the goal of ecological restoration is for the Great Lakes, noting that there are more than 160 invasive species in the area.) While ecological management and restoration activities might not be that fruitful, Carey said, it is important to monitor ecosystems and make an effort to minimize the negative effects that humans have upon them.

It is important to consider water temperature elevations in tributaries. Carey said that some reports indicate that fish in urban streams are affected by changes in water temperature.

Urban managers need a better understanding of how climate change will affect the frequency and magnitude of extreme events. It is common practice for urban planners to plan for extremes. These planners should be encouraged, Carey said, to go beyond existing design thresholds and analyze the impacts that could result if extreme events start to occur at an increased frequency.

Impacts to ground-water recharge are a major concern and should be further assessed. Carey said that more research should be performed on the impact that a changing climate and its associated effects will have on ground-water recharge. For example, it would be interesting to examine the relationship between increased wintertime rainfall and ice jams, flooding, and flow patterns under ice layers.

It would be wise to obtain more input from managers and users. When developing design scenarios, Carey said, it would be useful to obtain input from managers and users to ensure that relevant issues are taken into account.

Climate change should not be used as a scapegoat to mask poor management systems. Some communities are doing a poor job managing non-point sources and nutrient and sediment loading. Such communities should improve their management systems now. If a community has a poor management system, it would be dishonest for them to blame all of their loading problems on climate change.

It would be interesting to explore the way that climate change could affect a private investor's willingness to invest in municipal infrastructure. Some group members brought up some points about private investment. If municipal managers fail to adequately address climate change, they said, private investors may not be willing to invest in that community's infrastructure.

Resource/Resource Use

Jim Bruce opened by noting that the Resource/Resource Use Group wanted to offer the following feedback to the white paper authors:

The white paper did not clearly explain why climate change is expected to cause all of the negative effects that were cited in the paper.

Some recently-published articles and resources have not been incorporated into the white paper. Bruce said that group members could recommend some additional references.

More information should be provided on the way climate change could impact the agricultural sector. For example, information could be added about potential impacts to the livestock industry.

Information about the link between greenhouse gases and climate change should be included in the beginning of the white paper. While group members did not think it was necessary to engage in a discussion about mitigation measures, Bruce said, they did think something should be said about the role that human-induced greenhouse gas emissions play in climate change. Without this information, it will be difficult to convince people that they need to adapt to climate change. Bruce said that people need to hear the following: (1) humankind will be lucky if the world stays below 3.0 X CO_2 over the next 150 years, (2) there is going to be a major change in the energy balance of the earth surface, and (3) humans need to act now to address the situation.

Bruce said that group members spent time discussing some of the environmental changes that have already been observed in the Great Lakes area. Colleagues in Ontario, for example, reported that droughts and extreme-temperature events are occurring more frequently now. Other group members indicated that they have seen an increase in flooding events and high-intensity rainfalls. A representative from Walpole Island said that there are many cloudless summer days now, but that such events were rare during his youth. Also, the representative from Walpole Island reported increases in rare and endangered species populations, a phenomenon that some attribute to milder weather patterns. Another group member said that there have been some pronounced changes in seasonal water levels. While the overall change in water level has not been great over the long term, the group member said, the spring rise is occurring earlier in the year and water levels are dropping off earlier in Lake Ontario and Lake Erie. Another group member commented on the Niagara River, noting that flow has been declining since the 1970s, and that this has had a negative impact on the hydropower industry and has increased reliance on coal-fired generators which emit greenhouse gases. Another group member (i.e., John Lenters) said that evaporation has increased by 20 percent in Lake Ontario since 1948, but that water loss has been nearly offset by increases in runoff and rainfall. Another group member indicated that the recreational and tourist industries are already suffering from the effects of a warming climate, noting that the impacts have been particularly detrimental on the golfing and snowmobiling industry. Another group member said that crop insurance rates are record high in Ontario.

Bruce said that the following additional points were also made during the breakout session:

Adaptations that are designed to address short-term climate-variability events (e.g., El Nino) will help communities prepare for the long-term impacts of global climate change. Communities that develop support systems to address short-term climate variability, Bruce said, have taken the first step in developing adaptation strategies that can be used to address long-term changes.

The dates for the hunting and fishing season might require modification to account for changes that have been observed in seasonal events, such as fish spawning.

From an industry and human population perspective, it is important to ensure constant and continued access to high-quality water. Water availability has always given the Great Lakes area an advantage. Thus, it is important to ensure that water resources are protected.

Adaptations are already being made in the agricultural sector. Chicken farmers have started placing ceramic tiles on chicken coop roofs to keep the coops cooler. This point prompted group members to

enter into a philosophical debate about whether it is wise to promote adaptations that support agricultural practices that are already unsustainable.

Farmers in the Great Lakes Basin might have to abandon certain crops and start growing new ones. Bruce said that the group talked about the way that crop selection will be impacted by climate change.

Data indicate that high-intensity rainfall events have larger-than-expected impacts on erosion. Bruce said that the Soil and Water Conservation Society has recently published a paper that discusses the relationship between high-intensity rainfall events and erosion. The data presented in this paper were collected from several locations in the Northeastern United States. The results suggest that annual precipitation has increased by 1.2 percent over the last 10 years, but that the frequency of extreme rain events has increased by 7 percent and the frequency of high-intensity rainfall events has increased by 14 percent. In addition, the data indicate that the relationship between precipitation and erosion is not linear: a 10 percent increase in precipitation results in a 24 percent increase in erosion. Bruce said that these results are cause for concern, noting that huge amounts of contaminants enter water systems during erosion events. Bruce also said that the frequency of high-intensity rainfall events appears to be increasing on both sides of the border. Data collected in Canada suggest that high-intensity rain events are becoming more frequent. These data, which have not yet been published, suggest that the intensity of 30-minute rain events has increased between 1971 and 1995. Bruce concluded by saying that the erosion issue should be taken very seriously because modeling exercises indicate that the frequency of high-intensity rainfall will continue to increase as the climate changes.

Ecosystem Health Group

John Gannon, the facilitator for the Ecosystem Health Group, said that group members thought the white paper authors had done a good job synthesizing a large amount of complex material. There is one area where the paper falls short, however. It does not provide the information that would be most relevant to managers and users. While the paper did a good job discussing the first-line effects of climate change, little effort was made to take the report to the next step and discuss: (1) how contamination might impact wildlife, or (2) how additional loading could impact an entity's ability to meet acceptable Total Maximum Daily Load (TMDL) levels.

Gannon said that group members spent the bulk of their time discussing the following issues:

Better monitoring and surveillance programs are needed. Group members acknowledged that much is still unknown about the impact stressors have on the Great Lakes' beneficial uses. Thus, they agreed that a more robust monitoring program should be implemented to collect more data. The existing monitoring network, group members agreed, does not provide sufficient information about the changes that are being wrought upon the Great Lakes Basin. According to one group member, Gannon said, some excellent monitoring programs are currently in place in European countries and the Province of Alberta. It is time for the Great Lakes Basin, this group member said, to stop lagging behind and to start showing some leadership in the monitoring arena. The group advised soliciting help from volunteers, Gannon said, noting that a large number of educated professionals are planning to retire soon. It would be ideal if these retirees were willing to help implement an ecosystem monitoring program. Several examples of successful volunteer-based monitoring programs exist. Gannon advised drawing upon them to establish a monitoring program for the Great Lakes area.

People have already started observing changes. Gannon said that the Canadian public has noticed some changes. For example, they have noticed that outdoor skating rinks are less viable now and that the timing of some seasonal festivals have required shifting. A representative from Walpole Island also

indicated that changes are evident. For example, more islands are becoming visible in the area, a phenomenon attributed to decreasing water levels. Also, hunters on Walpole Island have noticed a shift in the timing of duck reproduction activities. For example, they are finding that some ducks are with young during the hunting season. As a result, many of the hunters have refrained from shooting ducks during hunting season.

The public needs to be educated about climate change issues. Gannon said that public perception often drives public policy. Thus, it is important to educate the public about the impacts of climate change. Doing so could generate an outcry for action.

Climate change should be considered when planning ecological restoration activities. Gannon noted that there is strong interest in implementing ecosystem restoration projects in the Great Lakes Basin. He said that it is important to consider climate change when developing restoration strategies. Failure to do so, could result in investments that do more damage than good.

Human Health Group

Alain Bourque said that the Human Health Group discussed the following topics:

Human health considerations extend beyond physiological concerns. Group members agreed, Bourque said, that quality of life issues and psychological well-being are important components of human health. Thus, during part of the discussion session, group members discussed the psychological and economic effects that climate change could have on quality of life. For example, certain behaviors that are linked to higher temperatures, such as crime and road rage, could become more prominent in the future and negatively impact quality of life.

It would be useful to discuss exceedences rather than focusing only on extremes.

It is important to clearly define what is meant by the phrase "climate change." Bourque said that some people think the term *climate change* encompasses changes that are caused both by natural forces as well as anthropogenic sources. Other people, however, just think that the term refers to the latter.

More information should be gathered on existing baseline conditions. Bourque said that a representative from Walpole Island made the following point: without a solid baseline, it is difficult to make conclusive statements about the changes that climate change induces.

Climate change could increase the spread of vector-borne disease. Group members agreed, Bourque said, that increases in temperature could cause increases in biological activity, including the spread of vector-borne disease.

When talking about climate change, it is important to talk about the changing characteristics of air masses, not just changing temperatures. Group members pointed out, Bourque said, that humidity levels and contaminant concentrations—both of which are expected to change as the climate changes—can have significant health implications. High temperatures are not the only cause for concern.

The white paper could have provided more information on the concept of ecosystem flips. Although the white paper does note that climate change will cause changes in species composition, the paper does not mention that some of the changes could result in rapid and dramatic ecosystem flips.

The white paper could have provided more information about the impacts that climate change could have on food-borne illnesses.

Hot weather could lead to a more sedentary life style. As temperatures rise, people might opt for a more sedentary lifestyle and simply go from one air-conditioned facility to another. Lack of exercise could lead to adverse health effects.

Impacts are likely to be cumulative in nature.

Valuable lessons can be learned from the past. To gain an understanding of how people might address future problems, Bourque said, it might be useful to analyze the processes used to address past problems, such as dealing with a specific pollutant.

People might be putting too much hope in "the medical solution" as a means to address human health concerns that relate to climate change. Bourque noted that people (especially Canadians) believe that modern medicine can take care of everything. When it comes to climate change, however, the medical community will not be able to provide for all who are impacted. It is important for society to think more about what needs to be done to deal with an overburdened health care system.

4.2 Additional Panel Comments

Mills thanked the panelists (i.e., the group facilitators) for their summary reports and asked whether they were surprised by any of the things they had heard during the discussion sessions. He also asked them to indicate whether they were surprised to find that certain topics had been omitted.

Krantzberg said that she was surprised that there had been so little discussion about the role that climate change could play in promoting alien species invasion and increased sediment loading. The latter issue is of great concern, she said, noting that it could have dramatic effects on lake levels and navigational practices. Carey responded by saying that this topic had been addressed by the Municipal/Urban Group, noting that it came up during their discussion on non-point source contributions.

Bourque said that he was pleased to find that people are now thinking about the ramifications climate change could have on human health. Ten years ago, climate change was not even on the radar screen for human health specialists. Now, there is plenty of concern over this issue.

Carey said that the Municipal/Urban Group members agreed that water issues will probably prove to be the most serious concern associated with climate change. They also recognized, however, that heat-related deaths are of grave concern as well, and that there is a disturbing facet to the heat-related-death story. Experience shows that a disproportionate number of the people who die from extreme heat events live in poor areas. This brings up an important point: the negative impacts associated with climate change might be felt in an inequitable fashion.

Before the discussion concluded, Bruce brought up one additional point: the efforts that are currently being made to regulate Lake Ontario's water levels might negatively impact ecosystems now that the spring rise is occurring earlier and seasonal water level drop-offs are occurring earlier as well.

4.3 General Discussion

Mills opened the floor to the general audience. The following topics were discussed:

Managing ecosystems. Gray said that he appreciated the point that the Municipal/Urban Group made about the difficulties associated with managing ecosystems. He agreed that it is arrogant to say that humans have the ability to manage ecosystems. He did question, however, whether the Municipal/Urban Group went too far in suggesting that it is futile to attempt to manage ecosystems. Gray said that he thinks it might be possible to manage very small ecosystems, such as small wetlands or small forested plots. Also, Gray said, he believes that humans have the power to modify their behavior in a fashion that is more ecosystem friendly. Carey responded by saying that he completely agreed with Gray's last point. While the Municipal/Urban Group did question humankind's ability to *manage* ecosystems, Carey said, group members were not questioning whether humans have the ability to change their behavior to reduce negative impacts on ecosystems. The group did not mean to imply that humans do not need to bother trying to reduce the stress that they place on ecosystems.

Use of the term "adaptation." Clark and Krantzberg said that they do not like the term *adaptation*. They agreed that the term implies that climate change will be easy to adjust to, that people will learn to live with it, and that society will be able to carry on business as usual. In some political circles, Clark said, adaptation might be interpreted as meaning "do nothing." While it would be better to use the term "strategies/responses" in lieu of adaptation, Clark said, he acknowledged that this was probably unrealistic since the word *adaptation* is already firmly established in the climate change lexicon. Clark said that the white paper should make it clear that adaptation measures will not completely eliminate problems. Krantzberg agreed. Bourque said that he is working on a document where the idea of adaptation is captured in the phrase "Limiting the Adverse Effects of Climate Change." Using a phrase like this, he said, helps make it clear that adaptation strategies do not offer a complete solution. Bruce defended the use of the term *adaptation*, noting that some climate change effects will be positive. The term *adaptation measures*, he said, is flexible enough to include strategies that minimize negative effects, as well as strategies that harness positive effects. Carey also defended the term and said that Clark's *strategies/responses* terminology is too limiting. He said that impacts can't always be addressed by strategies; at times, expectations will have to be adapted. Clark said that he would not object to the term so forcefully if there was at least some mention in the white paper about the importance of mitigation efforts. Mortsch said that effort does need to be made to make people understand that adaptation is not equivalent to a "do nothing" approach. She also noted that there is another term—adaptive capacity—that is emerging in the climate change lexicon. This term gets at the point that each country's ability to adapt may differ. Mills said that it is impossible to find perfect terms. The best way to clarify the meaning of terminology, he said, is to keep the dialogue going. Dave White concluded the session by making the following point: humans are the only species that can adapt. Who speaks for the other species that have no voice, he asked?

5. ADAPTATION TO CLIMATE CHANGE

5.1 Adapting To Climate Change

Joel Scheraga, EPA

Scheraga, one of the white paper's authors, delivered a presentation that explained why it is imperative for decision makers in the Great Lakes Basin to start implementing adaptation strategies to address climate change. Citing an IPCC document, he defined adaptation as follows: "Adaptation refers to adjustment in natural or human systems in response to actual or expected stimuli or their effects, which moderates harm or exploits beneficial opportunities." During his presentation, Scheraga explained why adaptation is important, discussed the basic considerations that should be taken into account when developing adaptation strategies, and offered recommendations to the Great Lakes Water Quality Board.

The Importance of Adaptation

Scheraga said that climate change poses a range of potential risks and opportunities. It is unclear how severe the impacts will be. He indicated that society is moving into unchartered territory: CO_2 levels are higher than they have ever been during the course of human history, and the levels are only expected to increase. Humans are playing a grand experiment with the earth's systems, he stated, noting that greenhouse gas concentrations are building at a rate that is more rapid than anything humankind has experienced before.

Scheraga said that the projected effects of climate change (e.g., higher temperatures, changes in precipitation patterns, and rising sea level) will exert impacts on a variety of systems that humans care about. For example, climate change will affect human health, agriculture, forests, water resources, coastal areas, and species and natural areas. In order to protect these systems, humans should strive to develop a balanced portfolio of mitigation and adaptation strategies. While mitigation strategies are important, Scheraga said, they are not the focus of the white paper. Instead, the white paper focuses on adaptation strategies. Some people are reluctant to talk of adaptation because they fear that efforts to implement adaptation strategies will detract from efforts to implement mitigation strategies. Scheraga claimed that the opposite is true: by implementing adaptation strategies, the public will become more aware of climate change issues and press more forcefully for mitigation strategies. There is another reason why focusing on adaptation measures is justified. Climate change is happening now, Scheraga said, noting that changes will continue to occur even if mitigation strategies are implemented today. Thus, because change is unavoidable, it makes sense for people to do what they can now to build resilience and decrease the vulnerabilities of natural and human systems. Compared to natural systems, Scheraga pointed out, humans are fortunate. While nature can only react to changes, humans can anticipate them and take action to reduce the negative effects that might result from the changes. Humans can also take advantage of the positive opportunities that could arise. Expanding on the latter point, Scheraga reminded workshop participants that some climate change effects could be beneficial and that it is foolish not to take advantage of the benefits.

While some policymakers agree that adaptation makes sense, Scheraga said, they claim that it is difficult for them to act since there is so much uncertainty about the rate and magnitude of climate change. Scheraga acknowledged that this is a difficult problem, but said that policymakers need to realize that failing to invest in adaptation today can leave regions vulnerable to severe consequences. As time goes on and the climate changes, it might become more difficult to protect sensitive systems. In addition, if policymakers fail to take climate change into account when they design new infrastructure, they may find that they are stuck with obsolete infrastructure that is incapable of addressing future stressors. When designing a new combined sewer system, for example, planners should take projected changes in precipitation patterns into account.

Scheraga noted that policymakers have asked the scientific community to make concrete predictions about climate change effects. Some of them have asked scientists to attach probabilities to anticipated outcomes. Policymakers say that this type of information will help them make smart decisions about adaptation strategies. While it is difficult to make concrete predictions with the tools that are currently available, Scheraga said, useful information can be obtained by running scenarios, performing "what if" analyses, and looking at historic analogs. Information provided from these sources should give planners enough information to at least start thinking about what needs to be done. Efforts should be made, Scheraga said, to improve methods for quantifying uncertainties, displaying uncertainties, and characterizing the implications for resource management decisions.

Basic Considerations in the Development of Adaptation Strategies

Scheraga provided a primer on some of the basic considerations that need to be taken into account when developing adaptation strategies. During the course of the discussion, he also identified barriers that make it difficult to get adaptation measures implemented. He said that the following should be considered:

Distributional effects. The effects of climate change will vary by location, sector, and demographic group. Care needs to be taken to ensure that adaptation strategies are targeted to address the right problem. As a result, adaptation strategies may need to vary from place to place. Scheraga used heat stress as an example. Experience shows that heat stress disproportionately harms the elderly, the young, the poor, and the infirm. Thus, when developing adaptation strategies, efforts should be targeted to these vulnerable populations. Scheraga also noted another complicating factor that relates to distributional effects: one person's negative impact might be another person's positive opportunity. For example, while decreases in snowfall might harm the skiing industry, such an outcome would help municipalities save money on snow removal activities.

Multiple stressors. Several of the Great Lakes' beneficial uses are already under stress from factors that have nothing to do with climate change, such as land use change and population growth. Climate change could exacerbate or ameliorate such stressors, a point that needs to be taken into account when developing adaptation strategies.

Cost. Many productive activities require funding. Unfortunately, dollars are scarce and resources that could be used to fund adaptation measures are often diverted to pay for other productive activities. Until adaptation is recognized as a vitally important activity, Scheraga said, other projects will be funded first. For example, in the face of a dramatic problem like AIDS, it is difficult to get the health care community to focus on the more insidious and less visible impacts of climate change.

The effectiveness of alternative adaptation strategies. Adaptation responses vary in effectiveness. They can vary from place to place or across demographic groups. Also, other stressors may impact the effectiveness of a particular adaptation strategy. Thus, care must be taken to perform a rigorous site-specific assessment of the efficacy of different adaptation strategies. In some cases, planners might find that an adaptation strategy needs to be augmented to address community-specific challenges. For example, when trying to identify the most appropriate strategy for preventing heat-stress-related deaths, community leaders might have to go beyond issuing heat advisories and set up a buddy system to ensure that elderly people are able to get out of their homes and into air-conditioned facilities.

Maladaptation. Planners need to realize that some poorly-designed adaptation measures can cause detrimental secondary effects. In such cases, Scheraga said, society might be better off if the adaptation measure is not implemented. He used hatcheries as an example. If hatcheries are used to enhance natural recruitment of fish stocks, this could alter or impoverish biodiversity and harm the genetic pool.

Pesticides provide another example. Many people think pest populations will increase as the climate changes. Some say that farmers can adapt by applying more pesticides. Doing so, however, will adversely impact water quality.

Multiple benefits. There are some sensible "win-win" measures that make sense to undertake whether or not climate change occurs to the full extent anticipated. Scheraga described these as the "low hanging fruit." Examples include: (1) improving watershed management to reduce flood and drought damages and protect water quality; (2) removing incentives for practices that place people, investments, and ecosystems in harm's way; (3) improving water pricing to increase efficient water use; (4) fostering continued adaptation in agriculture; and (5) establishing surveillance systems for vector-borne disease.

Scheraga said that adaptation is a difficult and complex endeavor. While it is easy to talk about it in theory, it is difficult to implement in practice. He said that efforts need to be made to build a bridge between the theory and the practice.

Improving Integration of Adaptation Into Decisions and Policy

Scheraga identified several concrete activities that the Great Lakes Water Quality Board could undertake to promote the development and implementation of successful adaptation strategies. These include:

Elicit information needs from decision makers. In order to develop successful adaptation strategies, Scheraga said, the Board needs to know who the stakeholders are and what endpoints stakeholders hope to achieve. He advised holding workshops and discussion forums to: (1) identify relevant stakeholders, (2) learn more about their needs and issues of concern, and (3) find out how they perceive climate change risks. Some work of this nature has already been performed, Scheraga noted, citing the Great Lakes Regional Assessment Team's workshops as an example. This team has held five workshops with different stakeholder groups. During the workshops, participants discussed the impact that climate change could have on water levels, lake ecology, agriculture, terrestrial ecology, and recreation. They also talked about the type of information they require to make informed decisions.

Better characterize uncertainty for decision makers and explain the implications of different outcomes. Scheraga recommended being clear about the uncertainties associated with climate change modeling. He also recommended investing more effort in quantifying uncertainties and helping decision makers understand the implications of uncertainty.

Develop better decision support tools. Scheraga said that many policymakers have told him that they do not know how to account for climate change in their day-to-day decision-making processes. To alleviate this problem, Scheraga recommended developing tools that will help resource managers gain a better understanding of: (1) the potential impacts of climate change, (2) how climate change fits within the context of other stressors, and (3) the implications and tradeoffs of different management decisions that are made under uncertainty. The latter, Scheraga explained, will help decision makers gain a better understanding of what is at stake when they make decisions. Some tools have already been developed, Scheraga said, citing EPA's TEAM Web-based Decision-Support Tool as one example. Another example is the Hantavirus Pulmonary Syndrome risk map that is being used in the Southwest to guide decisions about public health intervention.

Develop a communication strategy. Scheraga advised the Board to develop a communications strategy. The goal would be to make climate change a "real" issue for Great Lakes Basin stakeholders. Scheraga indicated that many stakeholders fail to see climate change as a salient issue that requires immediate attention. Other people feel powerless to respond because they think climate change is too large an

issue for humans to tackle. Thus, efforts should be made to help people understand that they have the ability to anticipate changes and implement adaptation strategies that will minimize harm and/or exploit opportunities. Efforts also need to be made to break down complex assessment findings into easy-to-understand information. Once stakeholders gain a clear understanding of the projected impacts, they will be ready to sit down and talk about adaptation strategies. Scheraga provided examples of the types of data that could be used to make climate change "real" for people. These include: (1) pictures depicting changes in ice cover in the Gulf of St. Lawrence, and (2) graphs that show changes in lake ice break-up dates over time.

Next steps: fostering the adoption of adaptation strategies. Scheraga said that this process involves six steps: (1) assess and evaluate potential adaptation measures, (2) choose preferred adaptation methods, (3) develop action plans, (4) implement the adaptation strategy, (5) monitor the adaptation strategy, and (6) reassess the strategy to determine whether any revisions are required.

5.2 Discussion

Ullrich opened the floor to discussion and welcomed the workshop participants to ask Scheraga questions. Workshop participants asked questions and offered recommendations. Some of their recommendations were directed to the white paper authors, some were directed to the Great Lakes Water Quality Board, and other recommendations were general in nature.

Questions

Do most U.S. scientists believe that climate change is "real"? Whiteye said that the U.S. media gives the impression that many U.S. scientists question whether climate change is really occurring. Scheraga replied that while there are skeptics, they do not represent the mainstream of scientific opinion. Scheraga claimed that most U.S. scientists do believe that climate change is occurring and that it will continue to occur. The debate, he said, revolves around the rate and the magnitude of the impacts and around determining what should be done to address the issue.

How can the Board advance the idea that adaptation strategies should be periodically reassessed after they have been implemented? Gannon reemphasized a point that Scheraga made at the end of his presentation: it is important to reassess adaptation strategies periodically to determine whether they need to be tweaked to increase their utility. Unfortunately, Gannon said, in the real-world, projects are rarely reassessed because people do not want to spend money on reassessment efforts. He asked whether the Board could do something to help ensure that reassessment is embraced as a key element of a project's implementation strategy. Scheraga said that it would be helpful to generate a strategic plan that provides a long-term roadmap. He said that the strategic plan should outline a 10-year or a 20-year strategy and highlight key implementation steps that are required along the way. Reassessment could be highlighted in the strategic plan as an important step in the implementation process. Scheraga said that efforts should also be made to educate people about the importance of reassessment activities and the negative effects that can result from canceling or delaying reassessment.

What will make people care about climate change issues? Carey said that he does not think it will be easy to convince people to take immediate actions to adapt to climate change. What are the key indicators, he asked, that will prompt people to take action? Can these indicators be identified so that the Board is prepared to act whenever the indicators become apparent? Mortsch said that the IPCC might discuss indicators of the impacts of a changing climate in its next report. Carey said that he was referring to indicators that will be important to the public rather than indicators that are only relevant to scientists. Audience members chimed into the discussion in an attempt to provide examples of the type

of indicators that Carey was referring to. They identified the following as indicators that could spur the public to action: deaths, beach closures, negative economic ramifications, and water shortages. As unfortunate as it may sound, Carey said, he fears that people will have to be confronted with these negative impacts before they will rally to support a coordinated adaptation strategy. Scheraga said that Carey's point was a good one, but one that he did not completely agreed with. Scheraga expressed optimism regarding the public's capacity to understand the relevance of climate change and to act before dramatic negative impacts become apparent. For example, he said, in the United States, the public is becoming more and more knowledgeable about the issue and some states (e.g., Massachusetts) are suing the federal government in an effort to encourage federal officials to place high priority on climate change issues. Clark, who shared Carey's skepticism about the public's existing level of comprehension, said that he thinks it is important to develop communication materials that clearly link negative impacts, such as death, with climate change.

Recommendations for the White Paper

Consider adding information about the economic ramifications of climate change. Clark advised including information in the white paper about the economic losses associated with climate change. Information of this nature, he said, is likely to grab the public's attention. Scheraga said that Clark's suggestion would be considered, noting that some information is already available on the subject. Mortsch indicated that the economic impacts of climate change still require a great deal of research, and that the white paper's lack of information on this topic reflects this.

Add information that will help decision makers gain a better understanding of which adaptation strategies are most likely to succeed. A number of adaptation strategies are listed in the white paper. Clark said that it would be useful to develop a rating system for the strategies, noting that this would help decision makers gain a better understanding of which strategies are most likely to succeed. Scheraga thought this was an excellent recommendation and said that some information could be included in the white paper to help shed light on the utility of different adaptation strategies. He did not, however, think it was possible to provide the type of detailed rating system that Clark recommended. At this point, Scheraga said, there is simply not enough known about the different adaptation strategies to say (at least with any level of certainty) which will perform best. Mortsch said that there are other factors that make it difficult to rate adaptation strategies as well. For example, the level of success that a particular adaptation strategy achieves might differ across sectors and across locations. Also, Mortsch and Scheraga noted, it is unclear how to measure success. What one person regards as success could be perceived by another as failure. Scheraga used water rights as an example. While an economist might perceive success in terms of achieving the most efficient allocation of resources, such an approach could cause social inequities and could be regarded as a failure by others.

Consider removing the points about combined sewer systems. Jiri Marsalek said that it is important to encourage planners to take climate change into consideration when designing new infrastructure. The white paper made this point, he said, noting that combined sewer design was used as an example to drive home the concept. Marsalek said that he thinks this example might be obsolete, noting that Canada is no longer designing new combined sewer systems and that he seriously doubted that new combined sewer systems were being developed in the United States. Scheraga thanked Marsalek for his point, but noted that *existing* combined sewer systems are still being revamped and expanded. The point that is important to make, Scheraga said, is that climate change (with its associated high-intensity rainfalls) should be taken into account when combined sewer systems are up for redesign.

Add more information about adaptation measures that can be used to minimize erosion. Citing a recent Soil and Water Conservation Society study, Bruce said that significant erosion is expected to occur as

the climate changes and high-intensity rainfall events become more common. This will cause large quantities of nutrients and toxic materials to enter the Great Lakes and will adversely impact water quality. Bruce said that this point should be emphasized in the white paper. In addition, more information should be added about adaptation measures that are designed to minimize erosion. Scheraga agreed that runoff will become a bigger problem as the frequency of high-intensity rainfall events increases. In February 2003, he said, EPA completed a study on the way that different types of riparian buffer zones can be used to reduce the effects of sedimentation.

Recommendations for the Great Lakes Water Quality Board

Create a booklet that discusses risk management guidelines that should be considered for the Great Lakes region. Bruce said that a booklet was developed under the Adaptation to Climate Change Program. The booklet, called *Risk Management Guidelines for the Caribbean*, helps decision makers in the Caribbean cope with uncertainty and risk in a systematic way. Bruce said that it would be useful if the Board created a similar booklet for the Great Lakes region. Scheraga agreed that such a booklet would have great value. It is not enough, however, to simply create and distribute educational manuals for decision makers, Scheraga said. In addition, decision makers require tools that will help them decide on a course of action and determine how much intervention to advocate.

Train consultants and other community-support professionals about climate change issues. Victoria Harris noted that an army of professionals help communities address land-use management issues, watershed management, water permitting issues, infrastructure design, and habitat protection issues. Most of these community-support professionals are poorly equipped to address climate change considerations or to promote adaptation strategies. This is because they have not received training and information about these issues. Thus, Harris said, it is important to train the people who are actually working with communities on a day-to-day level. She used the phrase "train the trainer" to summarize her points, and she advised the Board to sponsor workshops and training sessions to facilitate the effort. Scheraga thanked Harris for her comment and said that he was in full agreement. To support Harris' statements, Scheraga went on to say that it is critically important to make people understand that climate change is real and that it is happening now. Scheraga said that a communication strategy is a critical component to any adaptation strategy. People have to be convinced that climate change is a salient issue, a point that can be difficult to communicate. Even within EPA, he said, it has been hard to get colleagues to understand the immediacy of the climate change issue. For example, some people in EPA's Office of Water are putting climate change on the back burner because they feel that other issues require more pressing attention. Climate change will be viewed as a more salient issue, Scheraga said, once the Office of Water starts to realize the impact that climate change could have on TMDL requirements.

The Board should consider publicizing sustainability success stories. Gannon said that it would be useful to publicize examples of "win-win" adaptation measures. He advised providing information on measures that lead to improvements in overall ecosystem health. Scheraga agreed that the Board and the IJC are in a unique position to examine sustainability success stories and to release information about them.

General Recommendations

Promote the development of better probabilistic models. Beauchemin said that he thinks probabilistic modeling tools should be developed to help decision makers gain a better understanding of the likelihood of different climate change outcomes. Such modeling efforts are already underway in Europe. In order to create probabilistic tools for the Great Lakes region, Beauchemin said, Canadian

and U.S. modelers would have to make a concerted effort to work together, share data, and develop new models. He said that he did not see emphasis on such an objective listed in the United States' existing Science Plan. (He also noted that Canada does not have a Science Plan developed yet.) Scheraga acknowledged that the existing U.S. Science Plan does not highlight this modeling objective, but said that efforts are underway to incorporate this objective into the Science Plan. He noted that Jim Mahoney—Director of the U.S. Climate Change Science Program—is championing the effort and hopes to establish two modeling centers in the United States to perform scenario development activities. Although the topic is very much in the forefront, Scheraga noted, securing the dollars that will be needed to support modeling initiatives could prove to be difficult.

Make it clear that adaptation strategies will not fix everything. Mills revived the discussion that was held earlier in the meeting about the term *adaptation*. He noted that some people feel that the word has a connotation of incrementalism associated with it and that it could give one the impression that climate change can be easily managed if small incremental steps are taken to adjust to the changes. Such an interpretation is false, Mills said, noting that it is important to make people understand that fundamental change, rather than incremental change, will be needed to address the effects of climate change. Mills' comments spurred Scheraga to say that it is important to identify the endpoints that are of concern to different sectors. Once this is determined, he said, efforts need to be made to develop a sensible combination of mitigation and adaptation strategies to protect the systems that various sectors care about. One complicating factor, Scheraga noted, is the fact that the effectiveness of regional adaptation policies may depend on what is done at the national level.

Concluding the Discussion Period

Ullrich thanked Scheraga for his presentation and the audience for the spirited dialogue that followed. He concluded the session by saying that he thinks that some of the biggest impacts the Board and the IJC could have would be to make climate change issues real for people, help the public understand that climate change is happening now, and make the public realize that it has the ability to act in ways that will minimize the negative impacts of climate change. He said that the Board and the IJC have a unique opportunity (and responsibility) to elevate the climate change dialogue and to create power where there is currently a sense of powerlessness.

6. BREAKOUT SESSION #2—ADAPTATION TO CLIMATE CHANGE

Bratzel asked audience members to split back into their breakout discussion groups. A couple of adjustments were made to the groups: the Environmental Quality/Watershed Management Group combined with the Ecosystem Health Group and a new group, called the Walpole Island Group, formed. During the breakout sessions, Bratzel said, attendees should discuss adaptation strategies and identify concrete recommendations for the Great Lakes Water Quality Board. He presented the following as questions that could be used to spur the discussion:

Addressing climate change can be either reactive, in response to, or planned in anticipation of an impact. Also, there are a number of ways to intervene, for example, technology, education, economic incentives, official development plans, emergency planning, health advisories, stream rehabilitation. Based on your experiences, how can we anticipate and plan in advance, and to what endpoint? Based on your experiences, how can we intervene in order to adapt?

The white paper identifies specific adaptation options. How have you adapted? Were your choices correct? What constraints did you encounter? What consequences did maladaptation pose?

A number of factors conspire to limit our ability to act. These include, for instance, surveillance and monitoring, technology, infrastructure, and lack of perceived relevance to our health and well-being. Based on your experiences, what are the knowledge and information gaps, infrastructure and institutional limitations, and program and research needs? How can these be filled? What are the priorities? In an ideal world, what specifically would you like the Board to do to help you address climate change? What would be your "top 10" list? Please be specific in your advice and recommendations.

The groups were given 2 hours to discuss these questions and formulate recommendations for the Board.

6.1 Summary of the Breakout Group Discussions

At the end of the 2-hour session, Ullrich called the attendees back together and asked the breakout group facilitators to form a panel at the front of the room. Each provided a summary of the key messages, points, and recommendations that emerged during their breakout group discussions.

The Walpole Island Group

Dave White, a representative from Walpole Island, provided insight on climate change from the First Nation people's perspective. He opened by providing information about Walpole Island's 56,000-acre island cluster. First Nation people hold the rights to these lands; the land is their traditional territory and has never been surrendered to any other group. White said that the people of Walpole Island have a long history of embracing adaptive behavior. For example, aboriginal world views and traditions support the idea of moving from place to place to follow seasonal cycles and to avoid resource scarcity. Not all of the adaptations that aboriginal people have made resulted from natural causes, White said, noting that the people of Walpole Island have been forced to adapt to life on shrinking territory and are now confined to a small portion of their original homeland. In addition, the people of Walpole Island have been forced to adapt to pollution from upstream sources. Although new stressors are always being introduced, the people of Walpole Island have managed to maintain elements of their culture, maintain themselves, and sustain five major ecosystems and about 50 rare and endangered species.

White said that the people of Walpole Island have important rights. For example, groups that are interested in developing nearby lands must first consult with Walpole Island representatives. In addition, aboriginal people have other rights, such as treaty rights, and responsibilities. For this reason, it is imperative to involve aboriginal people in forums, discussions, and workshops. Involvement is important for another reason too: aboriginal people possess a wealth of information on ecosystems and rare and endangered species. This information is vitally important to the scientific community. Aboriginal people also possess detailed information about their surrounding lands and have a good understanding of which areas are most likely to be vulnerable to climate change impacts. White advised the scientific community to tap into this traditional knowledge to develop a better understanding of baseline conditions.

White said that the aboriginal people also have something else to offer: a worldview that promotes a more balanced approach toward the environment. While the conceptual model presented by the scientific community often advocates market-driven solutions, White said, it is unwise to rely on the market to drive decision making. Doing so, he said, is what got humanity into the mess it currently faces. As an alternative, First Nation people say that it is humankind's responsibility to maintain the balance between the thunderbird (which represent the sky and air) and the water panther (which represents the earth). Upsetting the balance between these two forces, White said, can cause catastrophic problems.

Resource/Resource Use Group

Bruce said that the Resource/Resource Use Group identified several topics that require further consideration. These include:

The potential for maladaptation effects. Group members noted, Bruce said, that climate change has the potential to increase agricultural pest populations. While increased pesticide usage could address this problem, such an approach would have negative secondary effects. Bruce advised collecting more information on the negative impact of pesticides before resorting to them as an adaptive solution. Specific questions that would be useful to answer include: (1) What impacts do pesticides have on human health? and (2) How large an impact is climate change expected to have on pest populations?

Developing better regional climate models for the Great Lakes. Bruce said that some global-scale climate models exist, but that they do not provide detailed information about the Great Lakes Basin area. Group members advised developing better regional-scale models that focus specifically on climate change impacts in the Great Lakes area.

Examining how climate change will impact the ability to reuse water. Group members agreed, Bruce said, that it would be helpful to gain a better understanding of the way that impacts to the hydraulic cycle could affect water reuse.

Developing ready-to-go adaptation action plans. Borrowing from the disaster mitigation community's philosophy, group members advised developing adaptation plans as soon as possible, even before the political support is in place to implement the plan. If disaster occurs, there will be public outcry for adaptation measures. If adaptation strategies are ready to go, then these strategies can be implemented before political support for the initiative evaporates.

Focusing on climate change effects that are occurring now. When trying to convince decision makers that adaptation is important, Bruce said, it would be wise to focus on climate change effects that are happening now rather than focusing on predicted outcomes. This will help policymakers understand that climate change is a real issue and that adaptation strategies should be implemented now rather than in the future.

Provide information about the economic losses that might be incurred if adaptation measures are not implemented. When presenting the cost of an adaptation strategy, Bruce said, it is important to also present information about the costs that could result if the strategy is not implemented. For example, when calculating the cost of expanding a storm sewer, estimates should also be provided of the costs that would be incurred if the expansion does not take place and flooding events increase as the climate changes.

Bruce said that the Resource/Resource Use Group identified several concrete recommendations for the Board. These include:

Develop a binational research and monitoring strategy. Group members think the IJC should advise the Science Advisory Board to develop a Science Plan for the Great Lakes Basin. As part of the Science Plan, efforts should be made to restore and improve the basin's monitoring networks. In some parts of the basin, Bruce said, data networks are in disarray. More effort needs to be made to monitor a variety of parameters, including lake temperatures, rain intensity, and evaporation.

Request government support to fill in knowledge gaps about potential climate change effects in the Great Lakes Basin. One group member, Bruce said, advised making sure that funds are specifically requested to support student research and hydrological monitoring.

Review lake-level regulation plans. There have been some shifts in the seasonal timing of water-level change events. This should be taken into account, Bruce said, when reviewing existing lake-level regulation plans.

Review Great Lakes policies through a climate change lens.

Develop and distribute risk management guidelines to educate policymakers about climate change and adaptation measures.

Focus more attention on erosion management and adaptations. Bruce recommended working with non-governmental organizations and investor groups to move forward with this agenda item.

Encourage governments to examine the impact climate change could have on human health.

Provide strong support for an educational program.

Provide information about how likely it is for projected outcomes to occur. Bruce said that IPCC classifies projected outcomes as highly likely, moderately likely, or unlikely. He recommended using this approach when analyzing projected outcomes for the Great Lakes Basin.

Municipal/Urban Group

Carey said that the Municipal/Urban Group identified the following as topics that require further consideration:

Realizing that political will is likely to be tied to a specific event. Carey said that high-impact events, such as catastrophic floods, raise awareness about the need for adaptation strategies. As a result, after such an event, the window of opportunity is open to implement adaptation strategies. For this reason, it

is important to have adaptation strategies thought out in advance and ready for implementation at a moment's notice.

Placing more emphasis on identifying true vulnerabilities. Group members recommended investing efforts in identifying vulnerable areas and estimating the risk of harmful results actually befalling these vulnerable areas.

Determining whether existing systems can be tweaked to address vulnerabilities. When developing adaptation strategies, group members agreed, rather than implementing a new system from scratch, it makes sense to examine existing programs to determine whether they can be modified to sufficiently address the risks posed by climate change.

Tapping into existing professional networks. Engineering professionals, health providers, bankers, and people in the insurance industry will all play a role in helping communities address the negative impacts of climate change. Thus, it makes sense, group members agreed, to engage these professionals in efforts to develop adaptation strategies.

Helping vulnerable communities deal with water scarcity issues. Some communities in the Great Lakes Basin could experience significant water scarcity problems as the climate changes. Efforts should be made, group members agreed, to identify these communities and develop targeted adaptation strategies for them. It might be difficult to get wide political support for such an endeavor, Carey said, noting that many people in the Great Lakes area find it difficult to believe that there could be a water scarcity issue because they are surrounded by so much water.

Strengthening non-point source management programs. Non-point source pollution has been a problem for many years, Carey said, but it is expected to become a bigger problem as the climate changes. Many non-point source control programs already exist. Efforts should be made to analyze the existing programs and determine what needs to be done to strengthen them.

Carey said that the Municipal/Urban Group identified several concrete recommendations for the Board. These include:

Encourage relevant parties to develop probabilistic models and make clear predictions. Carey said that the scientific community should provide concise messages about the impact that climate change is expected to have on the Great Lakes Basin. The public should not be expected, he said, to sift through confusing or convoluted messages. Group members agreed that the Board should put pressure on the scientific community to develop better predictions and clearer messages. This will require the development of better probabilistic models and predictive tools.

Connect existing models. If existing models are connected, Carey said, the scientific community will be in a better position to predict the effects of climate change. Group members specifically recommended connecting the regional climate model with the water-level model.

Encourage parties to improve their data storage practices and to share their data. Carey said that some important historical data have been lost. Efforts should be made to prevent similar losses from occurring in the future.

Develop more robust economic forecasts. When estimating the projected costs of climate change, Carey said, efforts should be made to calculate the cost of inaction as well as action.

Identify vulnerable groups and develop targeted adaptation strategies for them. Carey said that more vulnerability analyses should be performed.

The Ecosystem Health Group and the Environmental Quality/Watershed Management Group

Gannon said that group members from the Ecosystem Health Group and the Environmental Quality/Watershed Management Group identified the following as points that are important to consider:

Highlighting success stories. Group members thought it would be useful to distribute information about "win-win" sustainable success stories. At this point, they agreed, attention should focus on systems that were not originally designed with climate change issues in mind. Focusing on these stories will make decision makers realize that they might be able to tweak existing systems to accommodate for climate change. It will give people a "can do" feeling and an understanding of how adaptation for climate change could help address other non-climate-change related stressors. Emphasis on "win-win" situations, will help instill a feeling of power.

Training the trainers and the implementers. Group members agreed that trainers and implementers should receive education about climate change issues. This will help ensure that climate change and adaptation measures are part of the mindset early on in the planning process.

Working with the emergency response community and the watershed planning community to develop adaptation strategies.

Taking climate change into account when developing habitat restoration programs. Gannon said that the people who fund restoration projects need to have a better understanding of the way climate change could affect habitat restoration projects. It makes little sense to restore a wetland area, he said, if climate change modeling results suggest that the area is expected to dry up in the future. Efforts should be made to prioritize restoration projects and to implement those that are most likely to achieve success.

Gaining a better understanding of ecosystem function. Gannon said that it would be useful to obtain more information about ecosystem vulnerability and resilience to change. Such information would allow decision makers to target areas that are most vulnerable to negative effects and to intervene in these situations.

Communicating information about vulnerable areas to officials who administer environmental programs. Once researchers identify vulnerable areas, Gannon said, this information should be shared with officials who play a role in managing these areas. For example, officials who issue water permits should receive information about which areas are the most likely to experience water loss as the climate changes.

Promoting monitoring. Group members agreed that improvements need to be made to existing monitoring networks. They also agreed that it is important to identify champions for monitoring programs, and to link monitoring programs to specific indicators and endpoints.

Gannon said that group members identified the following recommendations for the Board:

Promote data sharing across the border. Gannon noted that there is little communication across the border. He advised inventorying information and trying to learn more about what is happening in

Canada and the United States. Lack of collaboration prevents both countries from obtaining a better understanding of ecosystems.

Publish lessons that have been learned about successful adaptation efforts. Group members recommended developing an adaptation portfolio, which includes tools, techniques, and real-world examples.

Human Health Group

Bourque said that the Human Health Group identified the following recommendations for the Board:

Recognize that climate change is a big issue and help make it more visible in the public eye. Group members indicated that the public requires more information about climate change issues and needs to understand that climate change is happening now. It would be useful, Bourque said, to provide data on the number of lives and dollars that have already been lost as a result of climate change.

Develop a marketing strategy and develop educational materials for a variety of groups. Group members agreed that the Board should embark on a concerted outreach effort. Bourque said that several different audiences require information about climate change issues, including the general public, decision makers, and industry representatives. A targeted marketing strategy should be developed for each group. Group members agreed that the general public should receive concise messages that let people know that they have the power to reduce harmful effects. For this audience, emphasis should be placed on "win-win" adaptation and/or mitigation strategies. One group member recommended using a slogan like "save energy, save money, save the environment." The general public needs more information, group members agreed, about the types of savings, either in tax credits or reduced energy costs, that can be realized by making environmentally friendly decisions. Group members also recommended releasing a list of things that people can do now to address climate change. They agreed that both adaptation and mitigation strategies should be included on the list, but that it is not necessary to differentiate between the two or to even use the words *mitigation* or *adaptation* on the list. Bourque said that a different marketing strategy should be used to make decision makers aware of the saliency of climate change issues. With this audience, he said, it is useful to find a champion to advocate the issue. As for industry members, Bourque said, group members talked about including them in an upcoming IJC meeting in an effort to gather more information about their perceptions about climate change. When communicating with industry members, emphasis could be placed on the business opportunities that might be realized by developing environmentally friendly products.

Develop a sound strategic plan. Efforts should be made to develop a strategic plan for the Great Lakes Basin. As part of this effort, care needs to be taken in clearly defining important questions, the definitions that will be used, the partnerships that will be tapped into, and the philosophies and values that will be adopted. In addition, the strategic plan should take the global picture into account and consider spatial and temporal scales.

Develop more tools. Group members agreed that it would be useful to develop better economic evaluations and better predictive tools.

7. FORMULATION OF ADVICE FOR THE BOARD AND CLOSING REMARKS

7.1 Summary of the Recommendations

David Ullrich, U.S. co-chair of the Great Lakes Water Quality Board

Ullrich thanked the speakers and the breakout group facilitators for the meaningful points and recommendations they offered over the course of the workshop. Their input, he said, will be consolidated and used to formulate advice for the Great Lakes Water Quality Board. The Board will use this advice to generate recommendations for the IJC on what to do about climate change in the Great Lakes Basin. Ullrich said that the information provided during the workshop would be mulled over and distilled over the next several weeks. At this point, however, he made a preliminary attempt to consolidate the workshop participants' recommendations. He said that they fall into five categories:

Promote education, outreach, communication, and marketing efforts. Major points expressed under this category, Ullrich said, were to: (1) recognize climate change as a serious issue, (2) communicate success stories, (3) train the trainer, and (4) understand ecosystem functions. The goal is to develop and disseminate information to a wide variety of audiences.

Develop tools. Ullrich said that he heard people recommend the following: (1) integrate the regional climate model with the water-level model, (2) develop better economic models, and (3) enhance the modeling community's ability to predict the outcomes of global climate change.

Support science. Under this category, Ullrich said, the following was recommended: (1) ensure that funds are available for student research, (2) promote monitoring efforts, and (3) preserve data. Ullrich said that it is also important to promote additional research on the impacts that climate change could have on the Great Lakes' beneficial uses.

Develop a strategy for addressing climate change issues. Recommendations included under this category, Ullrich said, included: (1) developing a ready-to-go plan so that adaptation strategies can be immediately executed when crisis emerges, (2) identifying groups that are particularly vulnerable, (3) prioritizing habitat restoration programs, (4) building in philosophies and values, (5) emphasizing partnerships, and (6) being clear about definitions and actions.

Implement strategies. Ullrich said that attendees stressed the importance of actually implementing strategies rather than regarding strategic planning simply as a paper exercise. Attendees also advised the IJC to release a list of easy activities that governments and/or individuals could undertake to address climate change.

7.2 Discussion

After presenting his summary, Ullrich asked audience members to let him know if he missed any key points. In response, White recommended asking the Board to explore and acknowledge the traditional knowledge that First Nation people possess. In many cases, he said, aboriginal people can provide important insight about vulnerable areas. He cited the example about the Inuit school that was buried by an avalanche. (This event was mentioned during Beauchemin's presentation.) He said that aboriginal people knew that the school was located in an unstable area and advised against building the school in that particular location. Their advice was not heeded, however. White advised merging aboriginal knowledge with western science. By collaborating, he said, it will be possible to obtain a more complete picture of what is happening and will empower policymakers to make better decisions. Other attendees strongly supported White's suggestion. In fact, Carey said that he thinks there is currently too much emphasis on modeling and not enough emphasis on observational knowledge, traditional knowledge, and monitoring efforts. He said that a greater effort should

be made to collect information from aboriginal communities as well as emergency response managers who work at the community level. He advised breaking the dependence on modeling techniques as the basis for risk assessment and planning. Carey indicated that he has little faith in models. Bruce said that he could not let Carey's negative comments about models go unchallenged. He countered by saying that models do provide very useful information. While there may be some discrepancies between modelers regarding the rate and magnitude of effects, Bruce said, the models do provide clear messages about trends and the directions in which changes are expected to occur. Thus, their role in helping policymakers make decisions should not be downplayed. Lenters said that he believes that observational knowledge and modeling are both very important, noting that they complement each other.

George Kuper said that he did not think that the taxonomy of ideas that Ullrich outlined provides an in-depth approach. He advised focusing the recommendations to the Board around the idea of going through a robust risk assessment and risk management process. Doing so, he said, will help risk managers make good decisions about how to address climate change issues. In the process of performing the risk assessment, he said, a variety of stakeholders will become involved and educated about climate change and adaptation issues. Beauchemin said that Kuper's idea had merit. Before approving expenditures for adaptation measures, he said, treasury boards will want to know exactly what level of risk they are addressing. Clark said that he believes that enough information is already available to move forth with decision making and adaptation strategies. He said that he fears that waiting for a risk assessment will delay important decision-making activities for 10 to 20 years. Carey agreed with Clark.

Carey offered a parting comment about the white paper. He noted that the authors had placed a great deal of effort into the paper's development and thanked them for an impressive product. Given the effort that the authors have expended thus far, Carey said, they should not be asked to perform additional work on the product. He advised the Board to accept the white paper as is. All of the recommendations for improvement could be consolidated, documented, and used to revise the paper at a later date if such a revision is deemed necessary.

7.3 Closing Remarks

Ullrich thanked the workshop attendees for their participation. He also thanked Bratzel for all of the work that he had done to make the workshop possible. Finally, he thanked the white paper authors for the terrific job they had done consolidating a large amount of complex material. In closing, he said that he thought that the workshop had been a success and was very informative.

APPENDIX A:

FINAL WORKSHOP ATTENDEE LIST

Workshop
Climate Change and Water Quality in the Great Lakes Region—Risks, Opportunities, and Responses

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APPENDIX B:

AGENDA

Workshop
Climate Change and Water Quality in the Great Lakes Region—Risks, Opportunities, and Responses
Agenda

Wednesday, May 28, 2003

9:00 AM	Registration Desk Opens
10:00 AM	**Welcome and Introductions** David Ullrich, U.S. Co-Chair, Great Lakes Water Quality Board Dennis Schornack, Chairman, International Joint Commission
10:05 AM	**Workshop Purpose** John Mills, Canadian Co-Chair, Great Lakes Water Quality Board
10:15 AM	**Impacts of Climate Change on Great Lakes Water Quality** Presentation of white paper findings. Linda Mortsch & Marianne Alden Open discussion
11:45 AM	**Instructions for Breakout Groups**
Noon	Luncheon Speaker – Georges Beauchemin – **Climate Change from a User's Perspective**
1:00 PM	**Breakout Groups – Implications of Climate Change Across the Great Lakes Region** Questions 1 & 2
3:00 PM	Break
3:15 PM	**Impacts Panel** John Mills, Moderator Breakout group highlights and panelist insights, followed by moderated discussion
5:00 PM	Adjourn

Thursday, May 29, 2003

8:30 AM	**Adaptation to Climate Change** A primer and presentation of white paper options. Dr. Joel Scheraga Open discussion
10:00 AM	Break
10:15 AM	**Breakout Groups – Adaptation to Climate Change** Questions 3 - 7
Noon	Lunch (on your own)
1:00 PM	**Adaptation Panel** David Ullrich, Moderator Breakout group highlights and panelist insights, followed by moderated discussion
2:00 PM	**Formulation of Advice for the Board** Dr. John Carey & David Ullrich, Moderators
2:45 PM	**The Board's Next Steps** Dr. John Carey & David Ullrich
3:00 PM	Adjourn

APPENDIX C:

MATERIALS FOR BREAKOUT SESSIONS—QUESTIONS AND PARTICIPANT LIST

CLIMATE CHANGE WORKSHOP
BREAKOUT GROUP QUESTIONS

Background

As workshop participants with expertise and experience in climate change, you play a key role, first, to validate, expand, and extend the information presented in the draft white paper; and, second, provide advice about how to address climate change. The breakout sessions are an opportunity for you to share your experiences. To stimulate discussion, we pose seven questions. The questions are not intended to be exclusive nor answered sequentially.

In addressing climate change, we want to take advantage of positive impacts, minimize negative impacts, and ensure compatibility among various interests. Each change, impact, intervention mode, and adaptation option poses opportunities, challenges, and barriers. In answering the questions, consider the following:

- Responsibility. Who does what, when, where, how, and why?
- Cost.
- Time frame -- short-term action? long-term investment?
- Adequacy of existing institutional framework -- legal, management structure, programs, and policies.
- Availability and adequacy of engineering and technical infrastructure.
- Impact on Great Lakes governance.
- The extent to which adaptation options and mechanisms exist (including those for other stressors) and can be utilized.
- Socio-economic considerations, including consequences and incentives.
- Consequences of implementing adaptation options on competing interests.

Changes

The white paper identifies projected climate changes.

1. Based on your experiences, what changes do you foresee in the short, medium and long term?

_____

_____

_____

Impacts

The white paper identifies impacts, both positive and negative, on the Great Lakes. Considering impacts in the broadest possible terms, including but not limited to food web alteration, human health, social, and economic ...

2. What impacts have you experienced?

_____

_____

_____

Planning and Intervention

Addressing climate change can be either reactive -- in response to -- or planned -- in anticipation of an impact. Also, there are a number of ways to intervene, for example, technology, education, economic incentives, official development plans, emergency planning, health advisories, stream rehabilitation.

3. Based on your experiences, how can we anticipate and plan in advance, and to what end point?

4. Based on your experiences, how can we intervene in order to adapt?

Adaptation

The white paper identifies specific adaptation options.

5. How have you adapted? Were your choices correct? What constraints did you encounter? What consequences did mal-adaptation pose?

Overcoming Barriers

A number of factors conspire to limit our ability to act, for instance, surveillance and monitoring, technology, infrastructure, lack of perceived relevance to our health and well being. Based on your experiences:

6. What are the knowledge and information gaps, infrastructure and institutional limitations, program and research needs? How can these be filled? What are the priorities?

7. In an ideal world, what specifically would you like the Board to do to help you address climate change? A “top 10” list. Please be specific in your advice and recommendations.

Breakout Groups

Environmental Quality / Watershed Management

[C] Gail Krantzberg
[R] Kelly Montgomery
Gary Gulezian
Don Haley
Victoria Harris
Bano Mehdi
Linda Mortsch
James Nicholas
Enos Whiteye

Ecosystem Health

[C] John Gannon
[R] Ann MacKenzie
Marianne Alden
Greg Jenish
Kennon Johnson
Ric Lawson
Katherine Silverthorne
Jordan West

Human Health and Related

[C] Alain Bourque
[R] Chris Hartnett
Milt Clark
Paul Gray
Adele Iannantuono
Dave Ullrich
Mike Williams
Julie Winkler

Municipal / Urban

[C] John Carey
[R] Doug Alley
Georges Beauchemin
Martin Jaffe
Beth Lavender
Jiri Marsalek
John Mills
Tim van Seters
Ed Watt

Resource and Resource Use

[C] Jim Bruce
[R] Mark Burrows
Alex Basiji
Jeanne Bisanz
George Kuper
John Lenters
Ellen Wall
Dave White

The Walpole Island Group

[C] Dave White
Kennon Johnson
Enos Whiteye
Mike Williams

Floaters

Marty Bratzel
Kate Moore

C = Facilitator / Panelist
R = Recorder